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Canaigre Investigations*

II. Dehydration of Bulk Lots of Canaigre Roots in the Locality Where Harvested†

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Introduction

Tannin is one of the critical war materials. Domestic supplies of tanning materials are being depleted steadily by increased demands and imports of some of these materials have been reduced and further reductions are possible. To meet this situation a government program has been in operation since 1937 in an attempt to find new domestic sources of tannin. The outline of this program discussed by Frey and Sievers[1] has been expanded for specific application to canaigre by Rogers and Russell[3] and need not be given in detail here. Canaigre (*Rumex hymenosepalus* Torr.) is one of the plants that has been under cultivation. Its large fleshy roots contain 10 to 35 per cent tannin on a dry-weight basis. The possibility of its use as a source of tannin received

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†This is the second of a series of papers reporting on various phases of cooperative investigations of canaigre as a source of tannin by the Bureau of Plant Industry, Soils and Agricultural Engineering and the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, United States Department of Agriculture, and the Texas Agricultural Experiment Station.

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the attention of experiment stations in the Southwestern States for many years in the last half of the past century. A serious attempt was made to use it commercially in 1891 and 1892 when several hundred car loads of the roots from the Southwest were exported, but this practice was not long continued. Since then the use of canaigre as a tannin plant had not received much serious consideration until the present program began.

Canaigre is indigenous to the Southwestern United States and Mexico; hence the sources of the natural supplies of the root are far removed from the regions where it would be used. This is an important factor in the economic production of tannin from this plant and no doubt was one of the reasons for the abandonment of the early attempts to utilize it.

The roots when first dug usually contain between 60 and 75 per cent moisture, most of which must be removed at or near the point of production to reduce transportation costs and to prevent spoilage in transit. The successful commercial use of canaigre therefore depends on the development of some practical method of drying the roots where they are grown or collected. This paper reports the results of experiments conducted at Sacaton, Arizona with that objective.

FIGURE I
Digging wild canaigre in the Queen Creek area near Sacaton, Arizona, June 1943.

Source of Roots

The area around Sacaton, Ariz., being typical of the regions where wild canaigre occurs, was chosen for a shredding and dehydration test which was conducted from May 25 to June 17, 1943.* Drying conditions in most of the areas where canaigre grows are ideal during the months of May and June. It seldom rains during that time; the humidity is extremely low; and there is generally abundant sunlight, heat and wind. Later in the season showers are more frequent and although the tannin content is reported to increase during the summer it is probably more practical to harvest the roots earlier when the weather is more favorable.

Wild canaigre was obtained from the Queen Creek region near Sacaton. The field had been used for crop plants at one time but had not been irrigated for several months previous to the time the roots were dug. The sandy soil was very dry even at a depth of 30 inches but the roots were large and succulent. (Figs. I and II). Most of the roots were found near the surface but occasionally some were taken as much as 36 inches below the surface. These deep roots probably developed from plants plowed under in previous years when the land was under cultivation. The roots were dug by means of long-handled, round-pointed shovels. The most practical procedure for the particular purpose was to remove the roots from large colonies of the plants rather than from scattered individual plants. The distribution of the roots in the area utilized was such that complete harvesting, if this were practical, would probably yield about 10 tons of fresh roots per acre. The roots were taken to Sacaton for processing as soon as possible after they were dug.

The second lot of roots used was obtained from cultivated canaigre, one year old, grown from wild stock. The roots were plowed out with a turn-plow running approximately seven inches deep, and picked up by hand. By this method of harvesting only 72 pounds of roots were obtained per man hour largely because the crop was very poor, the yield at the end of one year's growth being at the rate of only 2.5 tons of fresh roots per acre. A potato digger with some modification could no doubt be used for harvesting canaigre commercially.

Washing, Shredding and Drying

The roots were washed on an 8 x 12-foot platform of hardware cloth supported on a frame about 24 inches above the ground. The roots were dumped on one end of the platform and gradually worked across the screen under a water spray of moderate pressure. When the roots reached the far end of the screen they were removed in slatted boxes and after the surface moisture had evaporated they were weighed and sacked. The cultivated roots washed

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*Credit is due the U. S. Cotton Field Station at Sacaton, Ariz. for making certain facilities available and the Sossman Ranch which granted permission to harvest canaigre roots from wild plants on its premises.

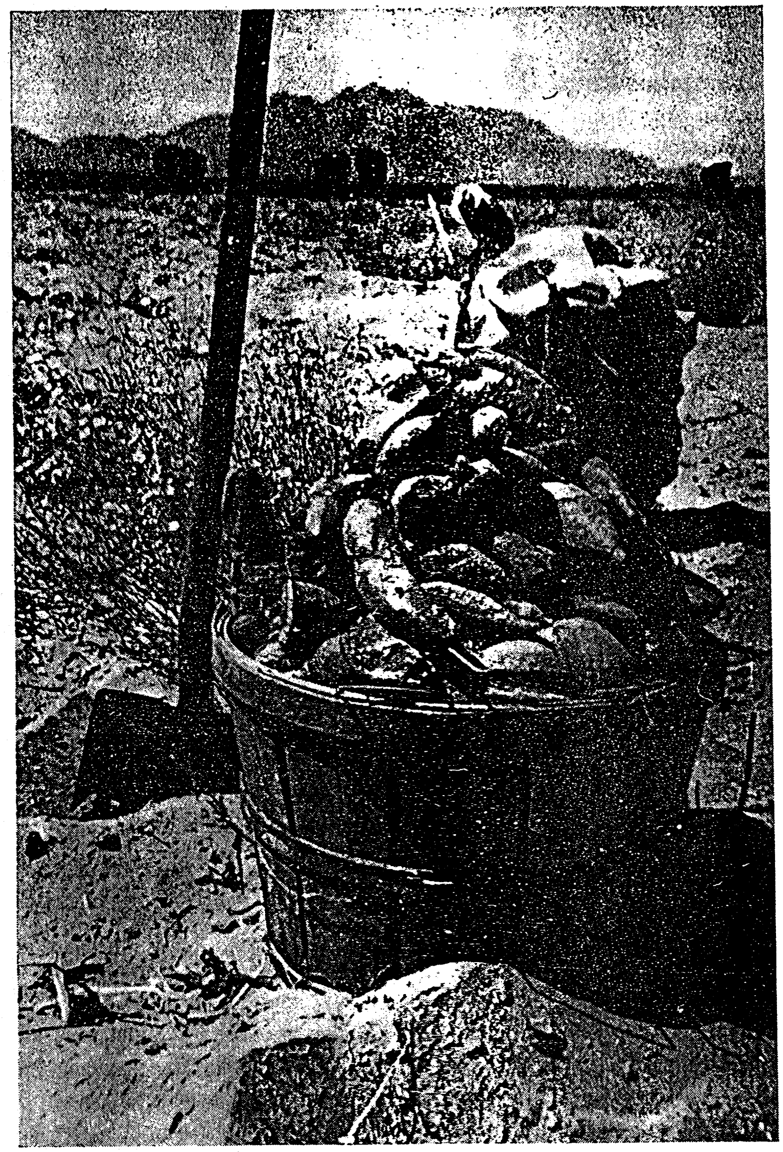

FIGURE II. A representative basket of wild canaigre roots.

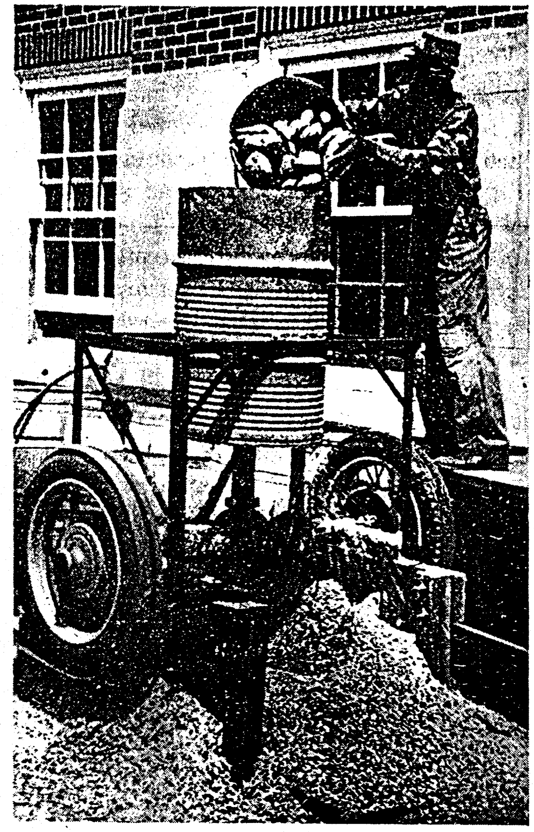

FIGURE III. The Kummer machine shown being used for shredding sweet potatoes: Photo by Alabama Polytechnic Institute.

more easily than the wild roots but neither presented any problem in washing since the soil to be removed was mostly sand.

The shredding machine used in the experiment was designed for shredding sweet potatoes (Fig. III)[2]. This machine*, built in accordance with the original specifications, failed to shred the canaigre roots but ground them to a pulp in the hopper with no material passing through the knives into the hamper. With slight adjustment† this difficulty was overcome and 2000 pounds of roots were shredded per hour by two operators. The shredded

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*The machine used in these experiments was built by the Arizona Flour Mills Company, Tucson, Ariz., Albert Lent, Manager, and was loaned to the Department of Agriculture for this purpose.

†The hopper of the machine was raised so as to provide a vertical clearance of 0.25-inch between the rotor which carries the knives and the stationary band inside of which the rotor revolves. This space permitted shredded pieces which did not pass through the knives to drop over the edge of the rotor.

material was slightly sticky but the pieces did not adhere to one another. Before drying, the shredded strips were leathery in texture and resembled short pieces of buckskin thong.

Immediately after each lot was shredded it was hauled to the drying surface in a pickup truck, the body of which was covered with a large canvas to prevent the shredded material from coming in contact with the metal. The shredded material was spread out on the drying surface, the use of iron tools being avoided as much as possible (Fig. IV).

Eleven lots of 1000 or more pounds each of the material were dried in the sun, using the playground of the Indian school at Sacaton as the drying surface. Two types of surface were available, one was made of small crushed rock bound with asphalt and rolled smooth while the other was of extremely smooth concrete. Also, one small lot of shredded material was dried on a piece of canvas placed on the ground in the shade.

At the outset of the drying it was planned to spread the shredded material at different thicknesses to determine the optimum amount that could be handled per unit area. However, since the available time for the test was limited and since it was desired to obtain a sizable quantity of material for analyses and tanning trials, it was spread at such depths as seemed to yield dry material most efficiently and rapidly. Complete data concerning the

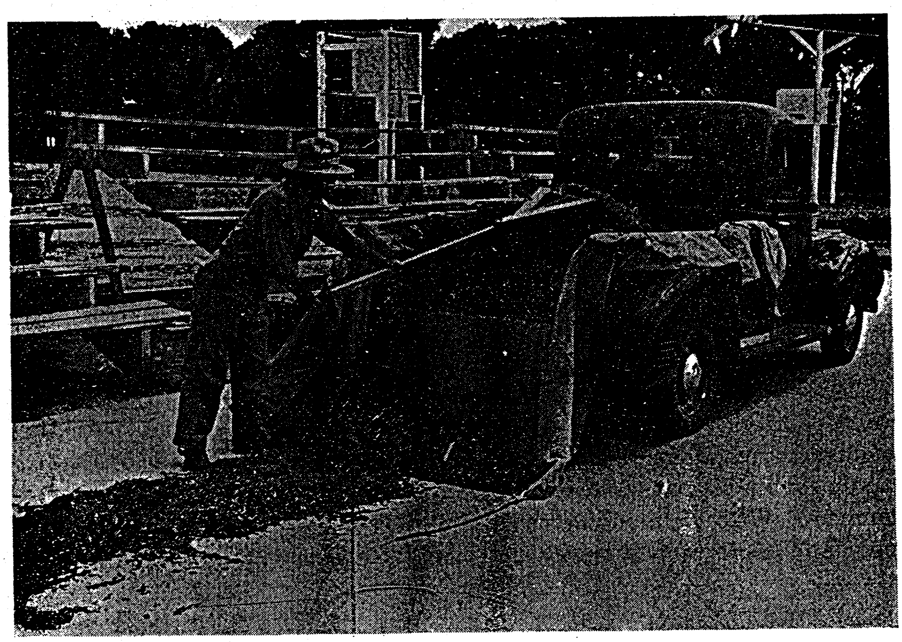

FIGURE IV, Spreading shredded canaigre roots on concrete at Sacaton, Arizona, June 1943.

TABLE I. DATA ON DEHYDRATION OF BULK LOTS OF PULPED AND SHREDDED CANAIGRE AND ANALYSES OF THE DRIED MATERIAL

Source of Roots and Lot Number	Conditions of Drying	Quantity of Material	No. of Times Turned	Drying Time*	Loss as Moisture in Drying	Total Solids	Soluble Solids	Insolubles	Non Tannins	Tannin	Purity	pH	Total Sugars
						Results on Moisture-Free Basis							
		Pounds per Square Foot		Hours	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent			Per Cent
WILD													
1†	On asphalt in sun	10.00	7	73	72.0	27.8	25.8	2.0	11.0	14.8	57.3	4.75	3.50
2	On asphalt in sun	5.00	7	71	74.7	32.7	30.6	2.1	13.2	17.4	57.8	4.66	4.42
3	On asphalt in sun	3.25	4	49	74.7	42.0	40.1	1.9	19.1	21.0	52.3	5 05	10.95
4	On asphalt in sun	2.50	3	43	74.8	45.4	43.9	1.5	20.6	23.0	53.1	5.10	12.04
5	On asphalt in sun	2.50	3	42	72.4	44.9	43.1	1.8	20.5	22.6	52.4	5.07	12.25
6	On asphalt in sun	1.25	3	28	74.0	48.0	46.5	1.5	22.3	24.2	52.0	5.16	13.49
7	On concrete in sun	1.00	2	28	72.4	46.6	44.7	2.1	21.0	23.7	53.0	5.21	12.27
8	On canvas in shade	1.25	2	48	63.6	48.8	47.5	1.3	22.4	25.1	52.8	5.17	13.13
CULTIVATED													
9	On asphalt in sun	2.00	3	26	65.7	37.1	35.5	1.6	14.9	20.6	58.0	5.30	6.08
10	On asphalt in sun	1.50	2	42	64.6	36.1	34.4	1.7	14.6	19.8	57.5	5.23	5.93
11	On asphalt in sun	0.75	2	42	64.9	35.5	33.6	1.9	14.1	19.5	58.0	5.33	5.25
12	On concrete in sun	1.00	2	24	66.3	37.3	35.4	1.9	14.7	20.7	58.4	5.33	5.99

*The drying time was taken as that period of time between spreading and sacking. In all cases except Lots 10 and 11 the time elapsed was reasonably close to the actual drying time required. Lots 10 and 11 were probably dry in a shorter time than recorded but were left on the drying surface an extra night.

†The roots in Lots 1 and 2 were ground or pulped while those in Lots 3 to 12 were shredded.

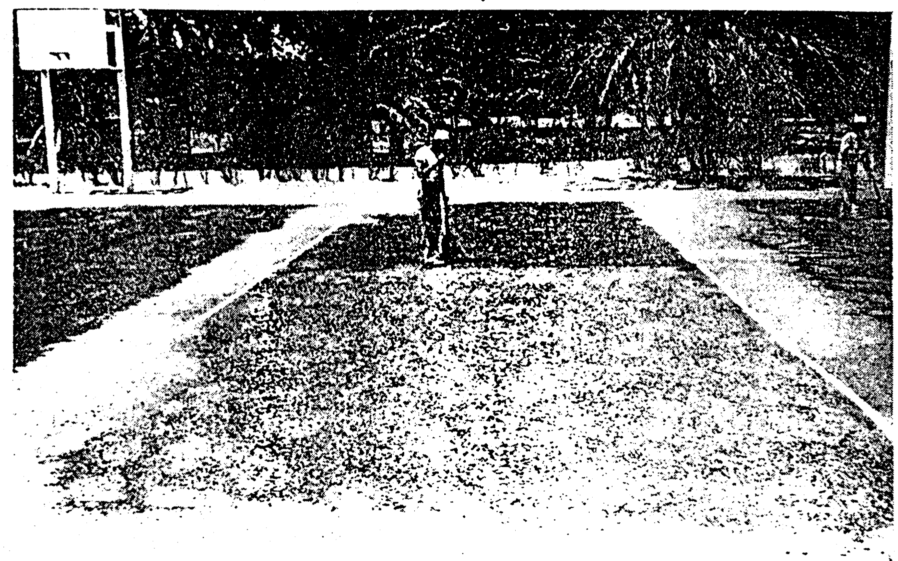

FIGURE V. Turning shredded canaigre roots, Sacaton, Arizona, June 1943.

drying treatments studied are shown in Table I. It was necessary to use an iron scoop for turning lots 1, 2 and 3 for the first few turnings; after that, an ordinary kitchen-type broom could be used. When spread thinly, as in lots 4 through 12, shredded canaigre can be readily turned or moved about with a broom (Fig. V). With a stiff-bristled barn broom about four feet wide, a workman could turn a ton of material in a few minutes.

The material used for lots 1 and 2 was obtained before the adjustments were made on the machine and was not properly shredded but ground to a pulp as stated. Although it was turned frequently some evidence of fermentation was observed, especially during the first hours of the drying period. It is probable that the thickness of the layers rather than the pulping of the material was mainly responsible for the fermentation. The dried material of these lots was dark in color and of poor appearance. There was no indication of fermentation in the case of lots 3 through 12 and a light-colored product was produced. The pieces were considered dry when they could be broken with a sharp-edged fracture.

The most efficient and rapid drying was obtained when the material was spread at the rate of approximately one pound per square foot of drying surface. At this concentration, and by turning it twice during the day, shredded canaigre dried after 24 hours under the atmospheric conditions prevailing at Sacaton during the time of the experiment. Climatic conditions at Sacaton were practically normal for the period while drying was in progress. The maximum temperature ranged from 90 to 105° F. while the minimum temperature ranged from 57 to 67° F. Temperatures taken at the surface of the layer of shredded roots were slightly higher than the air temperature. The relative humidity at 2 P.M. each day ranged from 13.5 to 22.0 per cent; the rate of evaporation per 24-hour period, from 0.242 to 0.385 inches; and the average wind velocity, from 1.39 to 2.80 miles. All drying days were perfectly clear except one which was partly cloudy with a very light shower—not enough to be recorded—falling in the afternoon. There was no appreciable difference in the rate of drying on the day which was partly cloudy.

With modifications, the procedure used to dry the roots could be adapted to a commercial scale. Mechanical washing could be accomplished by using a potato washing machine. The washing and shredding equipment could be combined into one unit, the roots being elevated into the hopper and the shredded material being removed continuously. The output of shredded canaigre in a given time could be substantially increased with such an arrangement. However, some tannin might be lost if wet roots were passed through the shredder and it may therefore be necessary to remove at least part of the surface moisture before shredding.

Sun-drying of shredded canaigre roots is effective and rapid. By spreading the shredded material at the rate of one pound per square foot and making two turnings daily, a drying surface of one acre would handle twenty tons of freshly shredded roots and yield about 5.5 tons of dry material each 24-hour period. The product thus obtained lends itself well to storing, shipping and extracting. For economy in shipping, the volume could be reduced somewhat by limited compression. Definite information on this point would be of value.

Analysis of Dried Shredded Roots

After the drying tests were completed and the data recorded, the twelve lots of roots were sacked and shipped to the Eastern Regional Research Laboratory at Philadelphia, Pa. where they were sampled and analyzed for tannin and total sugars. The results of these analyses and the data covering the drying treatments for each lot are recorded in Table I.

These results show the effects obtained by the different drying procedures. Deep piling, that is 10 and 5 pounds per square foot of drying surface, aided by the finely ground or pulped condition of the roots caused serious losses in tannin and sugar. Evidently the fermentation which took place destroyed more than half of the sugars and a considerable portion of the tannin. The data suggest that the tannin and sugar contents are highest when the shredded material is spread thinly and dried rapidly but, since repeated tests using the same depth of layer were not made, no definite conclusions concerning such relationship can be drawn. For the same reason it is possible only to point out that in the few tests made the nature of the drying surface had no pronounced effect on the tannin and sugar contents when the depth of layer was about the same. An interesting observation as regards cultivated roots is that canaigre cultivated one year from the wild stock showed less tannin and less sugars than were found in wild roots. As regards tannin this might be expected, since the wild stock contained older roots. The wild roots also contained more moisture than those cultivated, possibly due to being more deeply buried.

In drying the shredded cultivated roots, varying the concentrations on the drying floor from 0.75 to 2.0 pounds per square foot produced no material changes in either tannin or sugar contents.

Sheepskin color skivers were tanned with the water extract obtained from each of the 12 lots of roots. In all cases light colored, slightly pink skivers were obtained. Those tanned with the extracts from Lots 1 and 2, which fermented while drying, were darkest in color and those tanned with extracts from Lots 9 to 12, inclusive, the cultivated roots, were lightest in color.

Preliminary tanning tests, using powdered canaigre roots for direct tanning of light skins, have given encouraging results and indicate that canaigre in this form might find a place in light leather tanning. The results of canaigre tanning studies will be presented in later papers.

Summary

1. It has been demonstrated that canaigre roots can be shredded at the rate of one ton per hour with a Kummer shredder.

2. Drying finely ground or partially pulped roots spread at the rates of 10 and 5 pounds per square foot of drying floor resulted in fermentation and destruction of tannin and sugars.

3. Shredded canaigre roots were dried satisfactorily in the sun on asphalt and concrete in 24 hours under prevailing climatic conditions at Sacaton, Arizona, in June 1943, when the shredded roots were spread at the rate of 1.25 pounds per square foot.

4. Under drying conditions as favorable as those encountered one acre of drying surface would handle 20 tons of freshly shredded roots and yield about 5.5 tons of air-dry material each 24 hours.

5. Satisfactory color skivers have been obtained using water extracts from the shredded roots dried by the procedures described.

References

1. Frey, R. W., and A. F. Sievers. A Program on the Development of Domestic Tanning Materials. *J.A.L.C.A.*, 35, 647 (1940).

2. Kummer, F. A. Shredding Equipment for Drying Sweet Potatoes. Agr. Exp. Sta. Alabama Polytechnic Institute (Mimeograph) 1942.

3. Rogers, J. S., and G. A. Russell. Canaigre Investigations: I. A Review and Preliminary Studies. *J.A.L.C.A.*, 39, 467 (1944).

Discussion

R. L. MOORE: Mr. President and Gentlemen: The papers you have just heard on canaigre have certainly been very informative.

Canaigre is a type of tanning material that is greatly needed in this country at present. Being an acid producing tannin, it is a logical material to replace the fast dwindling supplies of our native chestnut, hemlock and oak on which our industry depended for its early development. It is of the class of tannins essential to the production of leather highly resistant to soil deterioration and wear. English sources state that canaigre produces a type of fiber very suitable for sole leather tannage.

Judging from the excellent progress made so far, we have every hope that the work of Mr. Rogers and his colleagues will disclose practical methods of growing, harvesting and processing canaigre and result in making available a supply of tanning extract that may free us from dependence on foreign sources of supply of the acid producing tannins.

In general, the tanning industry has been slow to take advantage of the vast amount of help that can be obtained through governmental cooperation on projects that are of vital basic interest to the industry. It seems to me that now is the time for tanners and extract manufacturers to give all the assistance possible to further this investigation as it gives promise of returning a rich reward to the industry.

L. SHEARD: Mr. President and Gentlemen: I think Mr. Rogers and Dr. Stevenson and their co-workers are to be commended on this paper and the information which they have given to us on canaigre.

When Dr. O'Flaherty asked me if I would join in this discussion, I looked up Procter, and, in his book published some 40 years ago, he gives much of the information mentioned by Mr. Rogers and Dr. Stevenson. I quote "This material in the wet state contains about 8 per cent of tan, giving a yellow-colored leather suitable for the production of retans and the production of harness leather." That opinion by Procter some forty years ago has been supported by what Mr. Rogers has told us. I personally think it is a very valuable material.

As Mr. Moore has just said, it can be very useful in mixing with other materials to produce acid in sole leather. Whether it can be economically made as an extract, of course, depends upon the location, how much they can produce per acre, and the transportation facilities, all of which will be taken care of in due course.

I think one of the main points is that other materials may become less available, and that this is one material that can be utilized in mixtures with other materials to produce a leather suitable for sole leather. This will help conserve the other materials and make them last much longer.

I desire to thank Mr. Rogers and Dr. Stevenson for their very excellent and valuable papers.

C. R. OBERFELL: What about this starch? Is it going to be necessary to remove that?

J. S. ROGERS: We have conducted some studies along that line and by following a special procedure have been able to leach canaigre without serious interference from the starch. However, we have not yet secured the desired leaching efficiency.

These samples may be of interest. The first is a sample of starch taken out of the roots. The second is a sample of the shredded root material after being dried. The third is a sample of vacuum drum dried extract prepared in our laboratory. This extract contains 53.4 per cent tannin and has a purity of 57. We have made extract that ran over 60 per cent tannin, and with a purity of between 60 and 65. There are difficulties still to be overcome in the processing of canaigre, but definite progress is being made in this direction.

I have here some samples of leather. This is a leather tanned with practically 100 per cent canaigre. In the first liquor tara was used to color the stock. These other two pieces are tanned entirely with canaigre.

OBERFELL: Is it going to be necessary to get rid of the starch before you can make a suitable commercial extract out of it?

ROGERS: Just what do you mean by getting rid of the starch?

OBERFELL: Can you leach the starch out?

ROGERS: The canaigre can be leached without previous removal of the starch. We have tanned leather in liquors containing starch.

OBERFELL: There is objection to having it in the extract so far as the tanning process is concerned?

ROGERS: We can produce the extract without starch in it.

OBERFELL: You can produce it, but is it going to be a detriment to the tanning process to have the starch in it?

ROGERS: We have not investigated this.

OBERFELL: Mr. Rogers, I am talking about the practical side of this. When you overcome some of these objections and arrange to deliver a half-million or more pounds to me, I will get it made into extract and make some leather out of it.

ROGERS: Fair enough.

O. REETHOF: What is the cost of canaigre cultivated in this country?

ROGERS: That is a question we cannot answer at this time. We don't have enough data. You saw what we did here. We handled probably ten to twelve thousand pounds of roots but we do not have production figures so we cannot figure the cost. That is a job that our cooperators at the Bureau of Plant Industry are going to do for us. We realize the necessity of establishing all these facts. We know that has to be done, and it is going to be done.

Reethof: The question of price is very important. This tanning material should not cost more than about 10 cents per tan unit in normal times. If it is too expensive, we cannot use it.

Rogers: If we cannot produce a domestic tanning material that will compare favorably with other tanning materials in quality and cost, then we shall not have succeeded in what we are attempting.

Moore: Is the starch of commercial value?

Rogers: We have not attempted to establish the commercial value of canaigre starch. We expect to be able to utilize both the starch and the sugar.

Oberfell: Why not make glucose out of it and sell it to the tanners?

Rogers: One thing I did not mention in the paper was that one of the samples of roots that we analyzed showed 18 per cent total sugars after conversion, and a study of these sugars showed 15 per cent was of sucrose.